



APPLICATION OF
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FOR LETTERS PATENT OF THE UNITED STATES
FOR IMPROVEMENTS IN
501 INK-SUPPLIED WIRE DOT MATRIX PRINTER HEAD

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INK-SUPPLIED WIRE DOT MATRIX PRINTER HEAD

SUCCESSORS BY BACKGROUND OF THE INVENTION

1. Field of the invention:

The present invention relates to an ink-supplied wire dot matrix printer head having wires supplied with ink at their distal end faces and movable against a sheet of print paper for transferring ink to the sheet in the form of dots to record a character, a figure, a graphic image or the like on the sheet, and more particularly to the construction of an ink tank and an ink guide for guiding ink from the ink tank to the distal end faces of the wires.

2. Description of the Prior Art:

Ink supply systems for a wire dot matrix printer are known in which no ink ribbon is used, but ink is supplied from an ink tank to the distal ends of the wire and transferred from the wires directly to a sheet of print paper. One known ink guide mechanism for such an ink supply system is disclosed in U.S. Patent No. 4,194,846 and comprises a porous member capable of absorbing ink and for guiding ink from an ink tank with wires contacting the porous member. The porous member contains fine holes with their sizes or diameters varying within a certain range, with the result that the ink absorbing capability varies from porous member to porous member, and excessive and insufficient quantities of ink tend to be supplied to the distal ends of the wire. The quantities of ink retained in the vicinity of the distal ends of the wires widely differ, and the porous member is liable to vary in dimensions or be deformed due to coaction with the sides of the wires. Therefore, the ink densities of formed dots are irregular.

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U.S. Patent No. 4,456,393 discloses another ink supply mechanism in which ink is supplied by a pump from an ink tank to the distal ends of wires. The disclosed ink supply mechanism is disadvantageous in that the construction of a joint between the pump and a printer head is complex and results in an increased cost. It is necessary to provide a sufficient seal so as to gain sufficient pump performance and a large-torque drive source is required for driving the pump. The ink supply mechanism is rendered particularly complex for a multicolor printer head, and such ink supply mechanism is not suitable for use with a small-size printer head.

FIGS. 9 and 10 of the accompanying drawings illustrate another known ink tank construction with an ink-impregnated member 160 such as of a porous material being enclosed in tank 140. The illustrated ink tank construction is of a simple shape and can supply a suitable amount of ink to a printer head body under appropriate capillary attraction by the ink-impregnated member. The ink tank can be impregnated with a large quantity of ink while preventing unwanted ink outflow from an air hole 142 and an ink supply port 141.

When ink is supplied from the ink tank of such a construction, ink in the tank remote from the ink supply port flows toward the ink supply port under a pressure difference developed between ink close to the ink supply port and ink remote therefrom as capillary attraction of the ink-impregnated member in the vicinity of the ink supply port is increased due to ink consumption. However, as can be seen in porous materials, ink-impregnated members are generally subjected to an increased resistance to ink flow and interrupted ink paths preventing a smooth ink flow as the quantity of impregnated ink is reduced. If the ink flow is blocked until a pressure differential sufficient to move ink in the ink tank is produced, then ink remote from the ink supply port remains retained and unused, resulting in a short ink supply duration.

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As shown schematically in FIG. 10, the ink tank frequently tends to trap air pockets in the ink-impregnated member. When ambient temperature rises or atmospheric pressure is lowered under such a condition, air communicating directly with the air hole expands and is discharged out of the air hole as indicated by the arrows A without applying any pressure on impregnated ink, whereas the completely trapped air is expanded as indicated by the arrows B while moving the ink surrounding it. When such air pocket reaches the ink supply port, an undesired ink outflow occurs. This causes a smear or ink spot on a sheet of print paper, or ink finds its way into a printer head mechanism, resulting in a malfunction.

P Accordingly, it is desirable to provide an ink-supplied wire dot matrix printer head which overcomes these problems associated with the prior art.

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P SUMMARY OF THE INVENTION

Generally speaking, in accordance with the present invention, there is provided an ink-supplied wire dot matrix printer head having actuating wires. Ink is supplied to the distal ends of the wires which are displaced into contact with a sheet of print paper to transfer the ink to the sheet and thereby form ink dots thereon. The ink-supplied wire dot matrix printer head includes a wire guide member having a wire guide hole for guiding the distal end of the wire, an ink tank containing an ink absorbing body therein and, an ink supply port in which a portion of the wire guide member is inserted. The wire guide member has a capillary ink path communicating with a side of the wire and supplied with ink from the ink absorbing body.

It is an object of the present invention to provide a high-quality and highly reliable ink-supplied wire dot matrix printer head of a simple construction which is capable of supplying a stable and appropriate quantity of ink from an ink tank to the distal ends of wires and is less subject to the influence of environmental changes such as temperature variations.

Still other objects, features and advantages of the present invention will become more apparent from the following description when taken in conjunction with the accompanying drawings in which preferred embodiments of the present invention are shown by way of illustrative example and not in a limiting sense.

The invention accordingly comprises the several steps and relation of one or more of such steps with respect to each of the others, and the apparatus embodying features of construction, combinations of elements and arrangement of parts which are adopted to effect such steps, all as exemplified in the following detailed disclosure, and the scope of the invention will be indicated in the claims.

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P BRIEF DESCRIPTION OF THE DRAWINGS

For a full understanding of the invention, reference is had to the following description taken in connection with the accompanying drawings, in which:

FIG. 1 is an exploded perspective view of a printer head according to an embodiment of the present invention;

FIG. 2 is a vertical cross-sectional view of the printer head shown in FIG. 1;

FIG. 3 is an exploded perspective view of an ink guide according to the present invention;

FIG. 4 is a perspective view, partly cut away, of an ink tank according to the present invention;

FIG. 5 is a side elevational view showing the manner in which said ink tank is mounted in place;

FIG. 6 is a vertical cross-sectional view of an ink guide according to another embodiment of the present invention;

FIG. 7 is an exploded perspective view of an ink guide according to still another embodiment of the present invention;

FIG. 8 is an exploded perspective view of an ink tank according to a still further embodiment of the present invention;

FIG. 9 is a perspective view, partly broken away, of a ^{an embodiment of the} conventional ink tank ^{in accordance with the invention.}

FIG. 10 is a schematic view illustrative of the manner in which air trapped in the ink tank of FIG. 9 is expanded; and

FIG. 11 is a schematic view of an arrangement of wires according to the present invention used with a seven-color printer.

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DESCRIPTION OF THE PREFERRED EMBODIMENTS

P A printer head according to the present invention is used in four-color printer plotter and a color image printer and has four-color ink systems and wires corresponding respectively to four ink colors. The four-color printer plotter employs black, red, green, and blue inks, and moves the head or a sheet of print paper or both and then projects a wire corresponding to a desired one of the colors against the print paper at a prescribed position thereon to form an ink dot. Desired characters and figures can thus be recorded by repeating the above cycle. In a color image printer using inks of four colors, that is, black, red, green, and blue, a sheet of print paper is scanned by a printer head in a direction perpendicular to the direction of feed of the print paper to form one-dot line in one scanning stroke, and the print paper is fed along by line pitches to record images. In seven-color printers, inks of four colors, that is, black, yellow, magenta, and cyan are used, and the colors of red, green, and blue are formed on a sheet of print paper by superposing inks of two out of the three desired colors other than black, thereby recording color images of seven colors.

The construction of a seven-color printer is schematically shown in FIG. 11. A printer head 70 is movable back and forth in the direction of the arrow X, and a sheet of print paper 71 is fed along successively by one line pitch in the direction of the arrow

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Y. An array of wire positions 72, 73, 74, 75 on the printer head 70 extends along a straight line inclined at an angle with respect to the scanning directions X, the wire positions being spaced in the direction Y at a pitch of $L \sin \theta$. Yellow-ink, magenta-ink, cyan-ink, and black-ink wires are located in the positions 72, 73, 74, and 75, respectively, to effect color-image printing free from undesired color mixing. Since a dot of one color is put on a dot of another color for mixed color formation, seven-color image printers are generally liable to suffer from unwanted color mixing because the ink of the former color is applied to the wire carrying the ink of the later color. According to the printer construction of FIG. 11, the ink of yellow which is most susceptible to the influence of the inks of the other colors is first applied to the print paper to prevent the inks of the other colors from being attached to the tip end of the wire carrying the yellow ink, thus avoiding the mixture of the yellow ink with the inks of the other colors.

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The present invention is concerned primarily with the printer head, and no further detailed description of the overall printer construction will be given.

FIG. 1 is an exploded perspective view of a printer head, and FIG. 2 is a vertical cross-sectional view of the printer head constructed in accordance with the invention. An ink tank, shown generally as 2, is detachably mounted by a holder 70 on top of a printer head body 1. The ink tank 2 is of a double construction composed of a first ink tank 2b for holding black ink and a second ink tank 2a which is divided into three sections for color inks. The inks are impregnated in ink-impregnated members 60 of a porous material which are enclosed in the ink tank 2.

For each ink, the printer head body 1 has in its front portion an ink supply guide 12, shown in Fig. 2, having ink guide grooves 12b with ends leading to the ink-impregnated member 60 and a wire guide 13 having a wire guide hole 13a in which a wire 11 is partly disposed. The ink supply guide 12 and the wire guide 13 jointly form an ink path from the ink tank 2 to the distal or tip end of the wire 11. The illustrated printer head is constructed for use in a four-color printer plotter or a four-color image printer, and there are employed four wires corresponding respectively to the four colors.

a *INS. 021*
a wire driver unit for each wire 11 includes a magnetic circuit comprising a yoke 18 having a coil core 16 around which a coil 17 is wound, a yoke plate 19, and a plunger 15. Movement of the plunger 15 is transmitted through a clapper 14 to the wire 11. The wire driver unit is covered with a cover 21 which limits the stroke of the clapper 14. In a standby position, the tip end of the wire is located back from a distal end surface of the wire guide 13, and the wire length is selected such that an ink meniscus formed in a front portion of the wire guide hole 13a covers the tip end of the wire.

An ink guide assembly, which comprises the ink supply guide 12 and the wire guide 13, will be described in greater detail with reference to FIG. 3.

The ink supply guide 12 has axial ink guide grooves 12b leading to the ink-impregnated member 60. Each of the ink guide grooves 12b has a width and a depth selected such that ink will be supplied continuously from the ink tank 2 as described later on. The ink supply guide 12 has on a front surface a circular groove 12a, connected to the ink guide grooves 12b through an inner portion 12c (FIG. 2). An end of wire guide 13 is placed in the circular groove 12a, defining gaps indicated at A, B (FIG. 2). There is only a small

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M. M.

Y. M.

gap between the wire 11 and the peripheral surface defining the wire guide hole ^{13A} in the wire guide 13. The ink is guided by capillary action from the ink tank 2 through the ink guide grooves 12b in the ink supply guide 12, and then through the gaps A, B between the ink supply guide 12 and the wire guide 13 to the tip end of the wire 11.

Any excessive ink on the front surface of the wire guide 13 is drawn under capillary attraction into cross-sectionally V shaped collection grooves 13b defined in the front and side surfaces of the wire guide 13 and returned into the tank supply guide 12 without smearing the print paper.

The ink tank 2 will now be described in detail with reference to FIG. 4.

The ink tank 2, or each ink tank 2a, 2b, comprises a tank body 40, two ink-impregnated members 61, 62 of a porous material placed in the space in the ink tank body 40, and a lid 50. Ink impregnated members are impregnated with ink under low atmospheric pressure ranging from 5 to 10 mmHg, so that air remaining in the porous ink-impregnated members will be reduced as much as possible to increase the amount of impregnated ink. The ink tank body 40 has a bottom 40a including a front ink supply port 41 and a front wall air hole 42 defined in a stepped portion thereof. The ink supply guide 12 projecting from the printer head body has an arm 12d inserted in the ink supply port 41. The bottom 40a of the ink tank body has in its raised surface a plurality of slots 45a, 45b, 45c communicating with the ink supply port 41 in confronting relation to the ink supply grooves 12b defined in the arm 12d of the ink supply guide 12. Although not shown, the slots 45a, 45b are joined together to form a single slot, which together with the slot 45c guides the ink into the ink supply grooves 12b. The ink tank body 40 also

has a side wall 40c having on its inner wall a plurality of vertical ridges 47 having lower ends held against the bottom 40a and upper ends kept out of contact with the lid 50. The ink tank body 40 further has a front partition 48 disposed behind the air hole 42 and in front of the ink supply port 41 and having one end joined to the side wall 40c. The tank lid 50 has on a lower surface thereof a plurality of longitudinal ridges 51.

The space or volume defined by the bottom 40a, the side wall 40c, the partition 48, and the lid 50 of the tank body 40 accommodates therein the two porous members 61, 62 as double layers. Porous members 61 and 62 are held in contact only by the raised surface 44 of the bottom 40a, the vertical ridges 47 of the side wall 40c, the partition 48, and the ridges 51 of the lid 50. Porous members 61 and 62 have different average pore sizes or diameters. The porous member 61 which has a larger average pore diameter is placed on top of the other porous member 62.

In the ink guide assembly and the ink tank thus constructed, the capillary attraction is successively greater along the ink path, that is, from the porous member 61 having the larger average pore size to the porous member 62 having a smaller average pore size, to the ink guide slots 45 defined in the raised surface of the bottom of the ink tank body, to the ink guide grooves 12b defined in the ink supply guide arm 12d, to the gaps A, B between the ink supply guide 12 and the wire guide 13, and to the gap between the wire guide 13 and the wire 11. The above capillary attraction path can be achieved by selecting elements having the following dimensions:

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- The average pore size of porous member 61: 0.4 mm
 - The average pore size of porous member 62: 0.3 mm
 - The width of the ink guide slots 45: 0.12 mm
 - The width of the ink guide grooves 12b: 0.1 mm
 - The gap between the ink supply guide 12 and the wire guide 13: 0.1 mm

Po The gap between the surface defining the wire guide hole 13a and the wire 11: 0.01 mm

P A construction for removably attaching the ink tank 2 will be described with reference to FIGS. 1 and 5.

a The head body 1 has a frame 30 including side walls extending from upper and back portions of the head body 1 and serving as a holder support 31. The holder support 31 has a holder support hole 32, a leaf spring 36 defined by two vertical recesses 33a, 33b and having a holder attachment hole 34, and a guide slot 35. A holder 70 has on each of its sides a cylindrical projection 71 rotatably engaging in the holder support hole 32 in the head frame 30 and a semispherical projection 72 engaging in the holder attachment hole 34. Each of the ink tanks 2a, 2b has a side disposed closer to the holder support 31 and having a cylindrical projection 49 engaging a lower edge of the guide slot 35.

The ink tank can be attached and detached through the above construction in the following manner:

The holder 70 is supported in the position shown in FIG. 5, and the ink tank 2 is inserted into the holder 70 in the direction of the arrow C. At this time, the ink tank 2 is not required to be accurately positioned in the holder ~~70~~ and hence can easily be inserted into the holder 70. Then, the holder 70 is turned in the direction of the arrow D to bring the projection 49 on the side of the ink tank 2 into contact with an edge of the guide slot 35 in the head frame 30, whereupon the ink tank 2 is positioned with respect to the head frame 30. Now, the ink supply port 41 is positioned correctly above the arm 12d of the ink supply guide 12 projecting upwardly from the head body. Continued turning movement of the holder 70 causes the arm 12d to engage in the ink support port 41 and

be inserted into the ink tank 2. The semispherical projection 72 on the side of the holder 70 on each side of the tank holder 70 engages and spreads the leaf springs 36 apart from each other. The semispherical projections 72 finally engage in the attachment holes 34 in the leaf springs 36, whereupon the leaf springs 36 return to the vertical positions to retain the holder 70 securely in position. At this time, the ink guide slots 45 on the bottom 40a of the ink tank 2 are disposed in confronting relation to the ink guide grooves 12b in the arm 12d of the ink supply guide 12, thus forming the ink path from the ink tank to the printer head body. The ink tank 2 can be removed in a procedure which is a reversal of the above attachment process.

Operation will now be described.

First, printing operation of the printer head will briefly be described.

CILT ~~FIG. 2~~ Referring to FIG. 2, when the coil 17 is energized, the plunger 15 confronting the coil core 16 is attracted. The clapper 14 to which the plunger 15 is secured, *moves* is turned to project the wire 11 which engages a distal end of the clapper 14. The tip end of the wire 11 *projects* through the ink meniscus, carries ink thereon, and hits a sheet of print paper (not shown) to transfer the ink to the printer paper. When the wire 11 is in a standby position, the tip end thereof is located inside of the end surface of the wire guide 13 so that an ink meniscus is formed in front of the tip end of the wire 11. Accordingly, ink is attached successively to the tip end of the wire 11 as the latter is *projected* and retracted. The transfer of ink to the tip end of the wire, and other details of an inked-wire dot matrix printing process are described in U.S. Patent No. 4,456,393 issued June 26, 1984, which is incorporated by reference and thus will not be described here in greater detail.

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a.
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Operation of the ink supply mechanism of the inked-wire dot matrix printer head according to the present invention will now be described.

For obtaining a proper dot density in inking of an ink dot matrix printing system, it is necessary to apply a continuous appropriate quantity of ink to the tip end of the wire. Therefore, the wire guide hole should have a proper dimension in the vicinity of the wire tip end and a proper amount of ink, without excess or shortage, can be supplied from the ink tank.

In the foregoing printer head construction, the ink guide path from the ink tank 2 to a position in the vicinity of the wire tip end is composed of slots, grooves, and gaps. By selecting suitable dimensions of the widths of the slots, grooves, and gaps, an amount of ink necessary for printing can be guided without an overflow under appropriate capillary attraction. Since the gap between the wire guide 13 and the ink supply guide 12 can be dimensioned to retain ink therein under capillary attraction, an appropriate quantity of ink can be supplied even when the ink supply from the ink supply grooves 12a suffers an ink shortage due to increased use of ink.

The dimensions of the ink supply grooves and gaps, the hole diameters of the porous members 61, 62, and the widths of the slots 45 are selected such that the capillary attraction is progressively greater along the ink path. Therefore, ink will not be interrupted in the ink path as described below.

As ink is consumed from the ink tank 2 during printing, ink flows from the porous member 62 through the ink guide grooves 12b, or through the slots 45 and the ink guide grooves 12b into the printer head body. Since the ink moves transversely across the porous member 62 at this time, the distance that the ink moves through the porous member

62 is small and no ink interruption occurs. When the ink supply in the porous member 62 is exhausted, a pressure difference develops immediately between the ink in the porous member 61 and the ink in the porous member 62. This is due to the difference between their average hole diameters, and the same quantity of ink as consumed is supplied from the porous member 61 to the porous member 62. No ink interruption takes place at this time since the ink moves transversely in and across the porous member 61. The amount of ink retained in the porous member 62 thus remains substantially the same as ink is fed out. Therefore, as the printing operation progresses, the ink in the porous member 61 is first used up, and then the ink in the porous member 62 is used up.

The ink guide mechanism in the printer head body operates to the same advantage. When ink flow in the ink path is interrupted due to vibrations or the like, the blocked ink is moved forward until it mixes with a preceding mass of ink since the capillary attraction is greater in the ink path than in the ink tank. Since the capillary attraction is greater in the vicinity of the tip end of the wire than the ink path where the ink flow is blocked, ink is not retracted from the tip end of the wire. Hence, the dot density will not be rendered unstable even momentarily, so that all ink on the wire tip end can be used up.

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With the foregoing ink tank construction, ^{of Fig. 4} the ink-impregnated members are supported on the ridges in the ink body, the ink-impregnated members are surrounded by a layer of air which leads to ambient air through the air hole. Since ink is impregnated under a low pressure, there is substantially no air layer or pocket enclosed by ink in the ink-impregnated members. Therefore, any expansion of

air in the tank caused by a temperature rise or a reduction in atmospheric pressure is released through the air hole, so that the pressure in the tank is equalized to atmospheric pressure and does not force the ink out of the ink tank.

The ink tank of the invention is therefore free from an ink outflow due to variations in temperature and atmospheric pressure, and capable of uniformly supplying ink.

The ink tank and ink guide path for supplying ink have dimensions dependent on the accuracy of the shapes of the components. Since the components can be formed easily with high dimensional accuracy by molding, the ink tank and ink guide path are highly dimensionally accurate and can supply ink uniformly. The ink tank and ink guide path can easily be assembled as they are composed of a small number of parts. They are free from wear and deformation for a long period of use and can keep initial performance partly because of the lubrication capability of ink.

FIG. 6 shows an ink guide member 12' according to another embodiment of the present invention. The ink guide member 12' is of an integral construction comprising the ink supply guide 12 and the wire guide 13 described in the preceding embodiment. The ink guide member 12' has an ink guide groove 12'b capable of guiding and holding ink for application to wire hole 12'a. The ink guide member 12' operates in the same manner as described with reference to the foregoing embodiment.

FIG. 7 is an exploded perspective view of an ink guide member 12" according to still another embodiment of the present invention. The ink guide member 12" includes an ink guide porous member 12"e disposed in the ink guide groove 12"b and serving as an extension of the ink-impregnated members in the ink tank into the ink guide path. Operation of the ink guide member 12" is essentially the same as that of the previous embodiments.

FIG. 8 is an exploded perspective view of an ink tank 2" according to another embodiment of the present invention. The parts other than a porous member 60" are the same as those in the embodiment shown in FIG. 4. The porous member 60" has different front and rear thicknesses so that the thicker front portion is compressed by the tank lid 50 when the porous member 60" is filled in the tank body 40. Therefore, even if the porous member 60" has uniform hole diameters, the front portion thereof has a smaller average hole diameter with the hole diameter becoming progressively greater toward the rear portion at the time the porous member 60" is placed in ink tank body 40. The porous member 60" is structurally equivalent to a plurality of porous sheet layers of different average hole diameters which are placed in the ink tank body 40 with the average hole diameters member 60". Therefore, operation of the porous member 60" is basically the same as that of the porous members 61, 62 shown in FIG. 4.

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While in the foregoing embodiment of FIG. 1 the ink tank is placed above the printer head, the tank may be located below the wires to achieve a stable printing density through the ink guiding process according to the present invention.

With the present invention, ink can be uniformly supplied through a simple construction from an ink tank to the tip end of a wire, and ink is uniformly attached to the wire tip end for producing a uniform and proper ink dot density. In the printer head of the invention, ink flow will not be interrupted in an ink guide path and prevents an ink supply failure. A quantity of ink absorbed in the ink guide path is smaller than would be absorbed with a conventional arrangement in which a porous member is used to apply ink directly to the tip end of the wire. Therefore, any wasted ink which is not used for printing is of a small quantity, and all the ink in an ink tank can effectively be used for printing. When the ink tank runs

short of ink, and the ink in the tank is rendered highly viscous by being dried at high temperature, or is solidified and thus failing to supply ink, a cartridge ink tank can be mounted in place so that fresh ink can immediately be supplied to the wire tip end for resuming desired printing operation.

According to the printer head of the present invention, no ink flow occurs due to variations in temperature and atmospheric pressure and a uniform ink dot density is produced. Unintentional ink flow out of the ink tank is avoided, thus avoiding smearing the print paper with the undesired ink spots. Ink will not enter the printer head mechanism, preventing malfunctioning. The cartridge ink tank can easily be detached and attached for ink replenishment.

Since the ink supply system of the invention is simple in construction, it takes up a small space. Where a multicolor printer head employs ink supply systems of the invention, the ink supply systems for different ink colors can be spaced widely so that mixing of colors can be avoided.

It will thus be seen that the objects set forth above, among those made apparent from the preceding description are efficiently attained and, since certain changes may be made in carrying out the above construction and method set forth without departing from the spirit and scope of the invention, it is intended that all matter contained in the above description and shown in the accompanying drawings shall be interpreted as illustrative and not in a limiting sense.

It is also to be understood that the following claims are intended to cover all of the generic and specific features of the invention herein described, and all statements of the scope of the invention which, as a matter of language, might be said to fall there between.